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AUTHOR Kilmer, Donald C.
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ABSTRACT

Third (part 3) in a set of four guides designed for the student interested in a vocation in electrical work, this guide includes four units: Unit VI--Ohm's Law, covering six lessons (voltage, current-flow and resistance, the Ohm's Law formula, formula for finding voltage, formula for finding resistance); Unit VII--Voltages, covering five lessons (DC voltage, AC voltage, frequency, step-down transformer, operation of a transformer); Unit VIII--Measuring Voltage and Current with a Meter, covering six lessons (ammeter rules, ammeter connection, reading milliamperes, voltmeter rules, voltmeter connection, multimeter); and Unit IX--Watt-Hour Meter (watt and kilowatt, reading a watt-hour meter, your electric bill, kilowatt-hour formula). Each lesson includes an objective, vocabulary, information about the lesson, an assignment, and illustrations. (For beginning units (I through V), see CE 014 109-110.) (SH)

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Basic Electricity

Part 3

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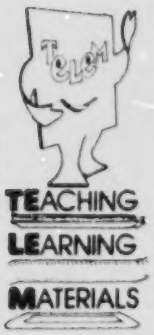

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UNIT VI

VOLTAGE --
VOLTS

$$E = I \times R$$

CURRENT --
AMPERES
or AMPS

Learn the formulas in this unit.

RESISTANCE --
OHMS

$$I = \frac{E}{R}$$

$$R = \frac{E}{I}$$

OHM'S LAW

UNIT VI – OHM'S LAW

What Is Voltage? Lesson 1

OBJECTIVE:

When you have completed this lesson you will be able to name the three basic components of electricity.

You will know what voltage is.

VOCABULARY:

component (kom-pō′-nənt) – a necessary part of something.
opposition (op-ə-zish′-ən) – action against something.
reduce (ri-dūs′) – make less; get smaller; decrease.
increase (in-krēs′) – make more; get bigger.

INFORMATION:

There are three basic parts to an electric circuit:

1. Voltage
2. Current
3. Resistance

Voltage is the *force or pressure* that *makes the electrons move.*

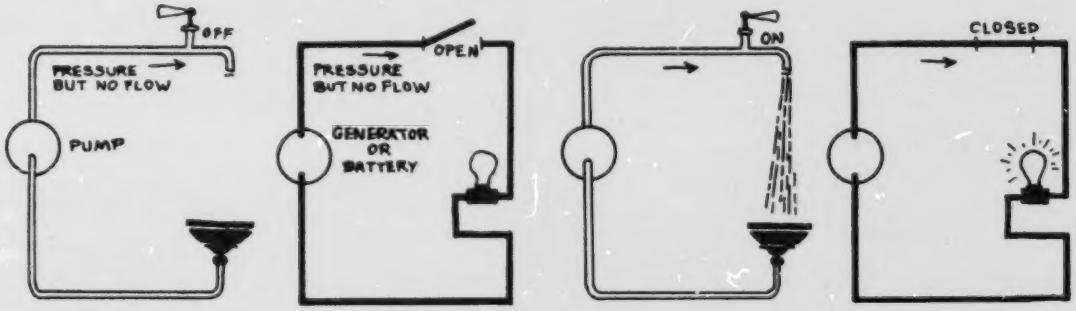
Current is the *number of electrons flowing.*

Resistance is the *opposition to the flow* of electrons – the force that cuts down the flow of electrons.

Your electrical system is something like a water system. A water pump will produce *water pressure*; a battery or electric generator will produce *electrical pressure.*

VOLTAGE IS ELECTRICAL PRESSURE

Study the following diagram for a better understanding.



Voltage is the force or pressure that moves electrons.

The first picture shows a water system under pressure but shut off. There is no water flow.

The second picture shows an electric circuit under pressure, but the switch is open and no current will flow.

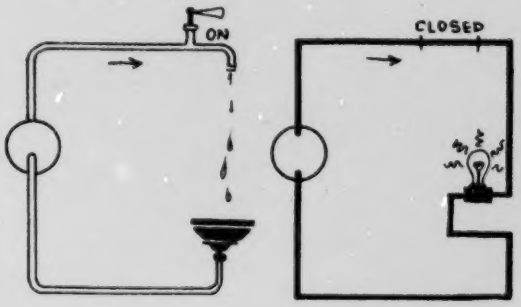
The third picture shows a water system under pressure with the faucet open and water flowing.

The fourth picture shows an electrical circuit under pressure with the switch closed and current flowing. The light is on.

The force or pressure that makes the current flow is called voltage. Voltage is measured in *volts.*

For a certain pump, the amount of water pressure stays the same. The valve in the faucet is the *resistance* to the water-flow. We can get *more water to flow* by opening the faucet more. This reduces the resistance.

For a certain battery or generator, the amount of electrical pressure stays the same. But we can get *more electric current* to flow by reducing the resistance of the circuit. Later on we will see how to do this.



Suppose we open the faucet fully and find not enough water is coming out. We can put in a better pump that will give *more pressure.* It will make more water flow.

If we do not have enough electrical pressure to light our bulb properly, we can connect two or three batteries so as to give *more voltage*. Then we will increase the flow of electrons through the light bulb. It will give more light.

ASSIGNMENT:

1. The force or pressure that makes electrons flow is called

   _____.

2. Voltage can be produced by a _____ or

   _____.

3. The number of electrons flowing is called _____.

4. The opposition to the flow of electrons is called _____.

5. Can we increase the flow of current by increasing the voltage?

   _____ (Yes or no)

6. Can we increase the flow of current by increasing the resistance?

   _____ (Yes or no)

7. Voltage is measured in _____.

Current-Flow and Resistance **Lesson 2**

OBJECTIVE:

When you have completed this lesson you will be able to explain the meaning of current and resistance in a circuit.

VOCABULARY:

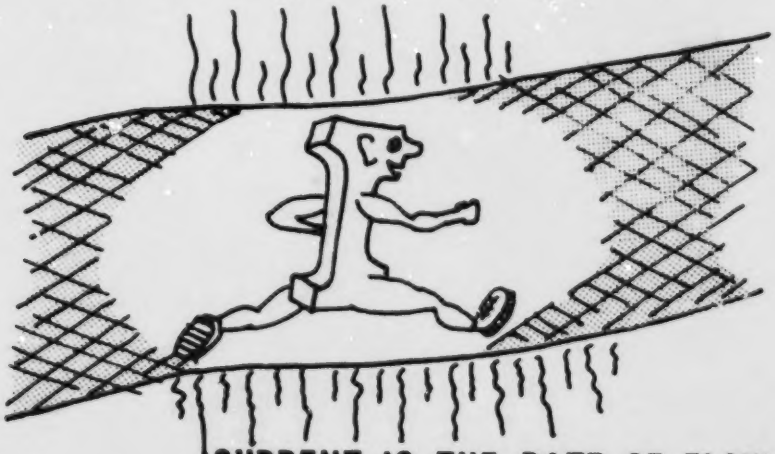
affect (a-fekt') – change; make larger or smaller; make better or worse.

INFORMATION:

We said before that *current* is the actual amount of electrons flowing in a circuit.

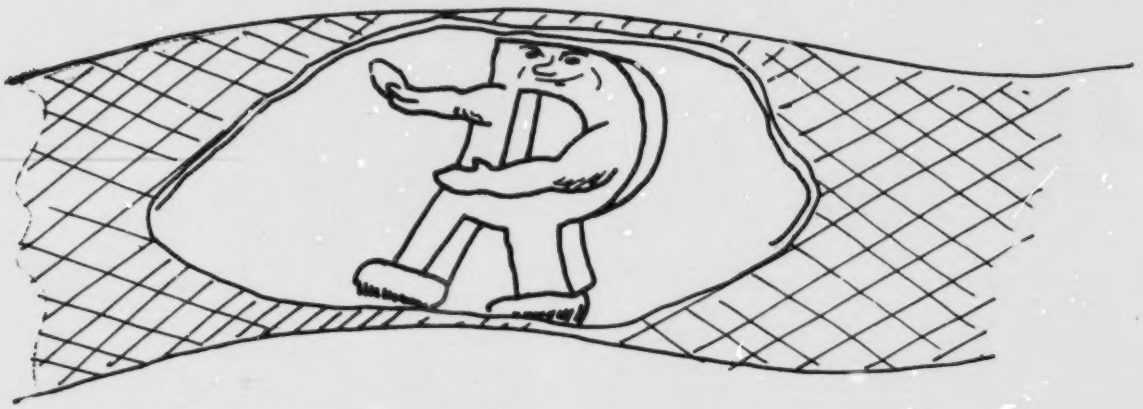
Current-flow is measured in *amperes,* or *amps* for short. Just how many electrons are we talking about here? Well, take a deep breath.

One ampere of current = 6,280,000,000,000,000,000 electrons passing a point in a wire in one second!



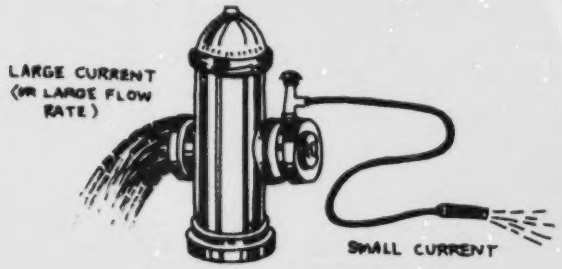
CURRENT IS THE RATE OF FLOW OF ELECTRICITY

We said before that *resistance* is the *opposition* to the flow of electrons. A small resistance lets electrons flow forcely. A large resistance reduces the number of electrons.



RESISTANCE IS OPPOSITION TO CURRENT FLOW

Look at the fire plug in the picture below.

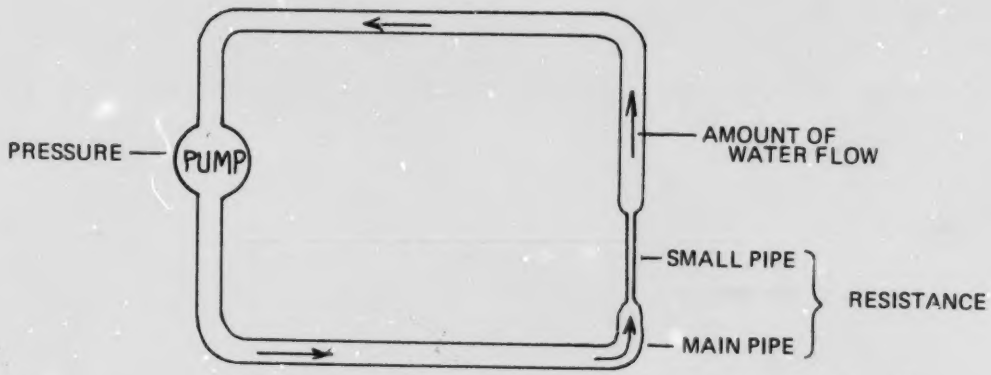


Compare the water-flow with two wires under the same pressure (voltage). You can see that a large wire would let electrons flow freely; a small wire would let only a small number of electrons flow.

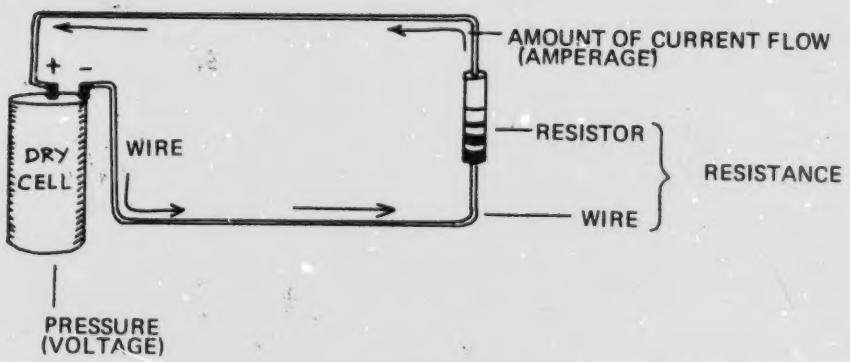
The size of the wire is only one thing that affects the resistance. The length of the wire does also. A longer wire increases resistance. Every light and appliance adds resistance to the circuit.

Resistance is measured in *ohms*.

Review of the three basic components of electricity.



A WATER CIRCUIT



AN ELECTRIC CIRCUIT

ASSIGNMENT:

1. The force or pressure that makes electrons move is called _____.

2. _____ is the flow of electrons.

3. The opposition to the flow of electrons is called _____.

4. What are the three basic components of an electric circuit?

   1.

   2.

   3.

5. Current is measured in _____.

6. Resistance is measured in _____.

7. Name three things that affect the resistance in a circuit.

   1.

   2.

   3.

8. Tell in your own words what current is.

UNIT VI – OHM'S LAW

The Ohm's Law Formula **Lesson 3**

OBJECTIVE:

When you have completed this lesson, you will be able to give Ohm's law in three different forms.

VOCABULARY:

constant (kon'-stənt) – staying the same, steady.

formula (fôr'-mü-lə) – a way of writing a rule by using letters or words or symbols for sentences.

E = Volts

I = Amps

R = Ohms

INFORMATION:

Ohm's law says that, when you increase the *voltage,* the *current* will increase. At a *constant* voltage, when you increase the *resistance,* the current will *decrease.*

Ohm's law can be written in three different forms. You can use them to find voltage, or current, or resistance.

Here are the three forms of Ohm's law. These are called formulas.

1. Voltage = Current X Resistance

2. $\text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$

3. $\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$

ONE VOLT IS REQUIRED TO PUSH ONE AMP THROUGH ONE OHM RESISTANCE

In electricity, a certain letter is used for each word.

1. Volts = E
2. Amps = I
3. Resistance = R

Voltage (E) is measured in volts.

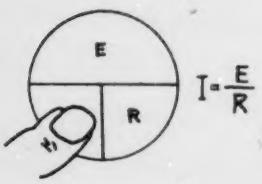
Current (I) is measured in amperes (or amps for short).

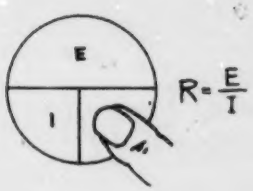
Resistance (R) is measured in ohms.

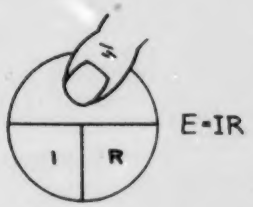
We can use the letters for the words in writing the formulas.

1. $E = I \times R$
2. $I = \frac{E}{R}$
3. $R = \frac{E}{I}$

Look at this picture. Your teacher will show you how to use it to remember the three formulas.







ASSIGNMENT:

Fill in the blank spaces below with the right word.

1. R = _____

2. I = _____

3. E = _____

Fill in the letter for each word in the blank space.

1. Current _____

2. Resistance _____

3. Voltage _____

Fill in the blank spaces with the right letters.

1. Resistance _____

2. Amps _____

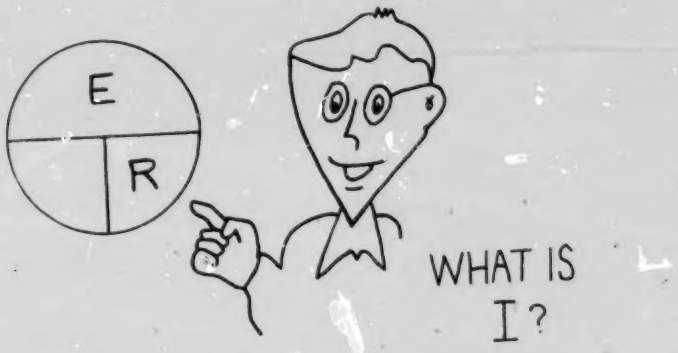
3. Voltage _____

4. Current _____

5. Ohms _____

6. Volts _____

Formula for Finding Current **Lesson 4**



OBJECTIVE:

When you have completed this lesson, you will be able to find the current in a circuit when you know the voltage and the resistance.

INFORMATION:

The formula for finding the current is:

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

or

$$I = \frac{E}{R}$$

Here are some problems we will practice with:

E = 10 volts

R = 5 ohms

I = ?

$I = \frac{10}{5}$ Answer: I = **2** amps

Solve this one yourself:

E = 25 volts

R = 5 ohms

I = ?

$I = \frac{25}{5}$ Answer: I = _____

ASSIGNMENT:

Fill in the blank spaces with the right letters.

1. The letter meaning voltage is _____.

2. The letter meaning resistance is _____.

3. The letter meaning current is _____.

4. Write the formula for finding the current (in letters):

   Words ⟶ Current = $\frac{\text{Voltage}}{\text{Resistance}}$

   Letters ⟶

5. Find the current in a circuit when:

   E = 120 volts

   R = 10 ohms

   I = ?

6. What will be the current in a circuit if a battery supplying 12 volts is connected to a resistance of 24 ohms?

Formula for Finding Voltage **Lesson 5**

OBJECTIVE:

When you have completed this lesson, you will be able to find the voltage in a circuit when you know the current and the resistance.

INFORMATION:

The formula for solving for the voltage is:

Voltage = Current X Resistance

or

$E = I \times R$

Here are some problems to practice on:

I = 3 amps

R = 6 ohms

E = ?

E = 3 X 6 Answer: E = 18 volts

Solve this problem:

I = 2 amps

R = 12 ohms

E = ?

E = 2 X 12 Answer: E = _____

ASSIGNMENT:

Fill in the blank spaces with the right words.

1. I is the letter for _____.

2. R is the letter for _____.

3. E is the letter for _____.

Below is the formula for solving voltage.

Voltage = Current X Resistance

4. Write the formula for voltage, using letters, not words.

_____

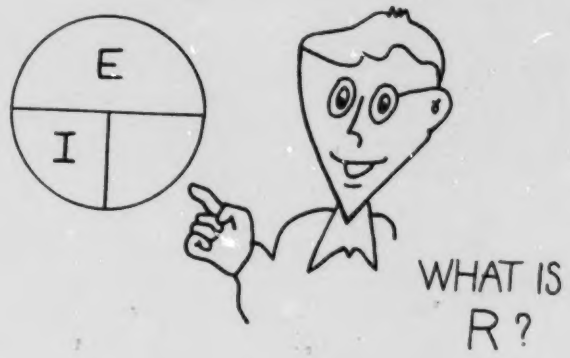
5. Solve for voltage when

I = 6 amps

R = 18 ohms

6. A mechanic's "trouble light" has a resistance of 100 ohms. How much voltage is needed to make a current of 1 amp flow through the light?

Formula for Finding Resistance **Lesson 6**



OBJECTIVE:

When you have completed this lesson, you will be able to find the resistance in a circuit when you know the voltage and the current.

INFORMATION:

The formula for solving for the resistance is:

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

or

$$R = \frac{E}{I}$$

Here are some problems to practice on:

E = 90 volts

I = 3 amps

R = ?

$R = \frac{90}{3}$ Answer: R = 30 ohms

Solve this problem:

E = 120 volts

I = 6 amps

R = ?

$R = \frac{120}{6}$ Answer: R = _____

ASSIGNMENT:

Fill in the blank spaces with the right letters.

1. The letter for resistance is _____.

2. The letter for voltage is _____.

3. The letter for current is _____.

Below is the word formula for solving for resistance.

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

4. Write the letter formula for solving for resistance.

_____

5. Find the resistance in a circuit when

   E = 125 volts

   I = 5 amps

6. A voltage of 6 volts is applied to a circuit. If a current of 2 amperes is wanted, how much resistance must be put into the circuit?

UNIT VI – TEST

Write the correct word for each of the three letters.

1. I = _____

2. E = _____

3. R = _____

4. Voltage is measured in _____.

5. Current is measured in _____.

6. Resistance is measured in _____.

7. I = 2 amps
   R = 30 ohms

   E = _____

8. R = 22 ohms
   I = 5 amps

   E = _____

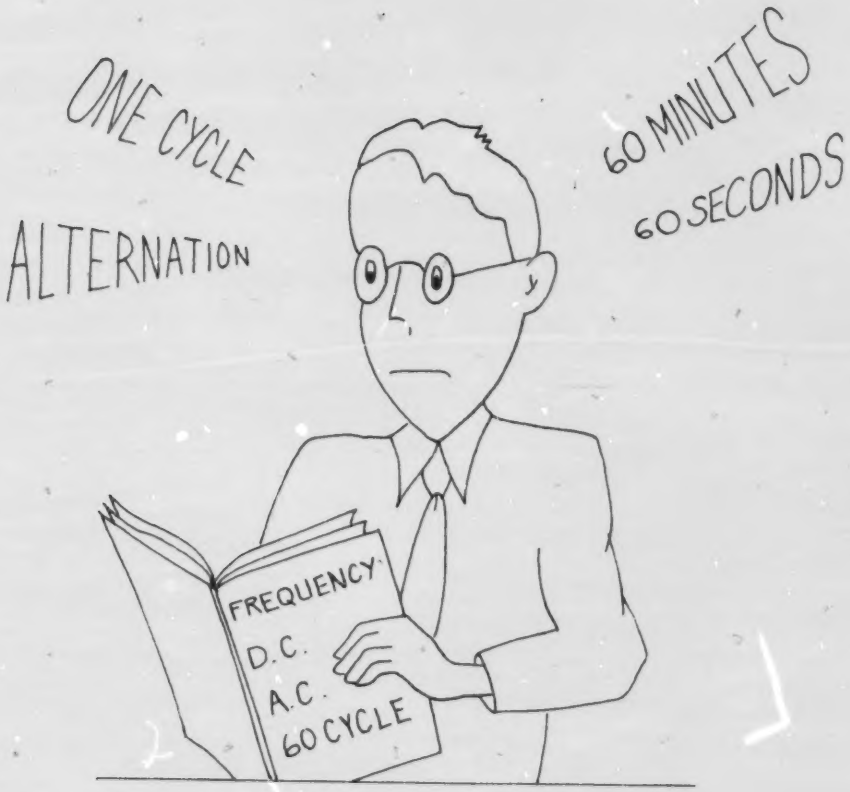
9. E = 100 volts
   I = 2 amps

   R = _____

10. E = 120 volts
    R = 10 ohms

    I = _____

UNIT VIII



VOLTAGE

UNIT VII – VOLTAGES

DC Voltage **Lesson 1**

OBJECTIVE:

When you have completed this lesson, you will be able to describe how DC voltage works.

VOCABULARY:

energy (en'-ər-ji) – power to do work.

alternate (ôl'-tər-nāt) – go first one way then the other.

direct current (di-rekt' kur'-ənt) – electric current that moves in one direction only.

terminal (tėr'-mə-nəl) – the place on a battery or appliance where a circuit wire is attached.

INFORMATION:

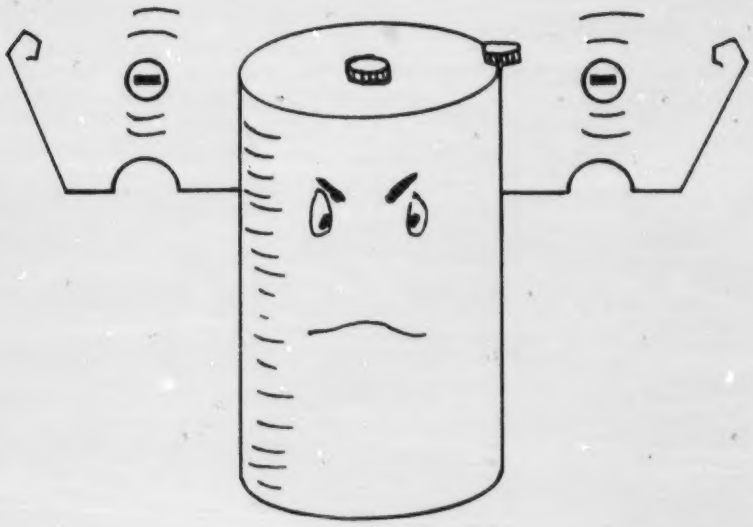
Voltage is *energy, pressure*, or *force.*

As we know, voltage pushes electrons through the wires.

There are two kinds of voltages:

1. DC voltage – produces direct current
2. AC voltage – produces alternating current

The battery produces DC voltage.



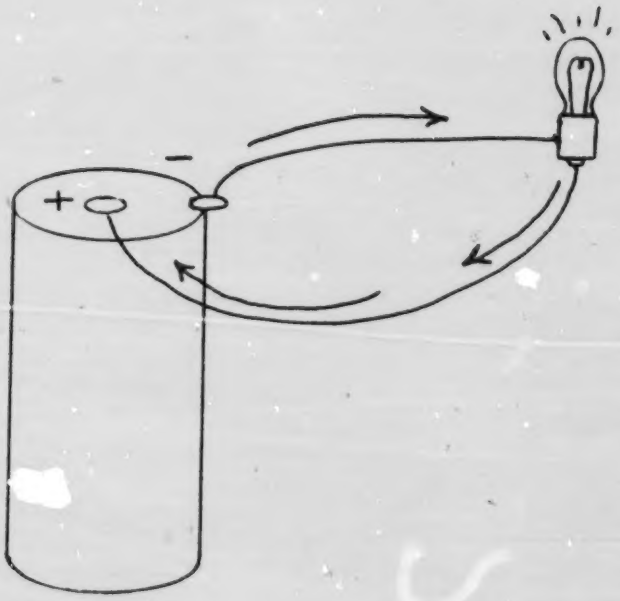
BATTERY

Source of Electrical Energy

DC voltage pushes electrons in one direction *only*.

The electrons move from the *negative* (–) terminal (pole) to the *positive* (+) terminal (pole).

This is an example of a DC circuit.



DC Circuit

The arrows show the current or electrons moving in one direction — from negative to positive.

ASSIGNMENT:

1. Voltage is _____.

   a. force
   b. energy
   c. pressure
   d. all of these

2. Voltage pushes _____ through the wires.

   a. bulb
   b. electrons
   c. battery
   d. terminals

3. Name two kinds of voltages.

   a. _____

   b. _____

4. What pushes the electrons through the wires?_____

5. In a DC circuit, electrons move from the _____ terminal to the _____ terminal.

6. What is the source of DC energy?

UNIT VII – VOLTAGE

AC Voltage **Lesson 2**

OBJECTIVE:

When you have completed this lesson, you will be able to describe how AC voltage works.

VOCABULARY:

cycle (sī'kl) – When something keeps changing and coming back to where it started, the time it takes for this to happen *once* is called a cycle.

terminal (tėr'-mə-nl) – a place on a generator to connect electrical wires.

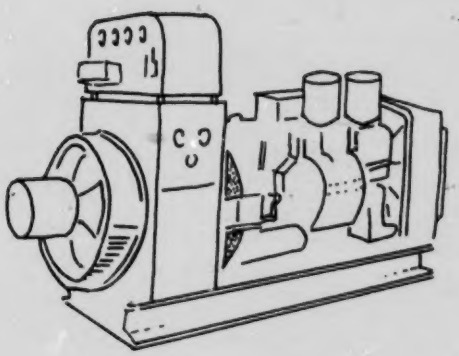
generator (jen'-ər-ā-tər) – a machine that produces electricity from other kinds of energy.

INFORMATION:

AC means *alternating current. Alternating* means moving *back* and *forth.*

AC voltage is the energy used to make electrons move back and forth in a circuit.

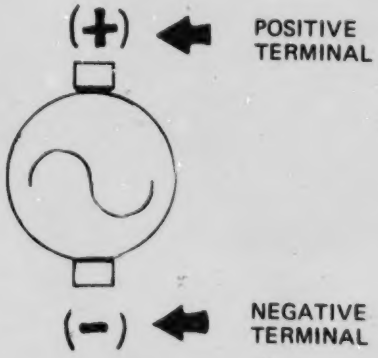
The AC voltage *generator* produces the energy to push and pull the electrons.



AC GENERATOR

AC GENERATOR (SYMBOL)

There are two terminals on an AC generator; one terminal is positive (+) and the other terminal is negative (–).

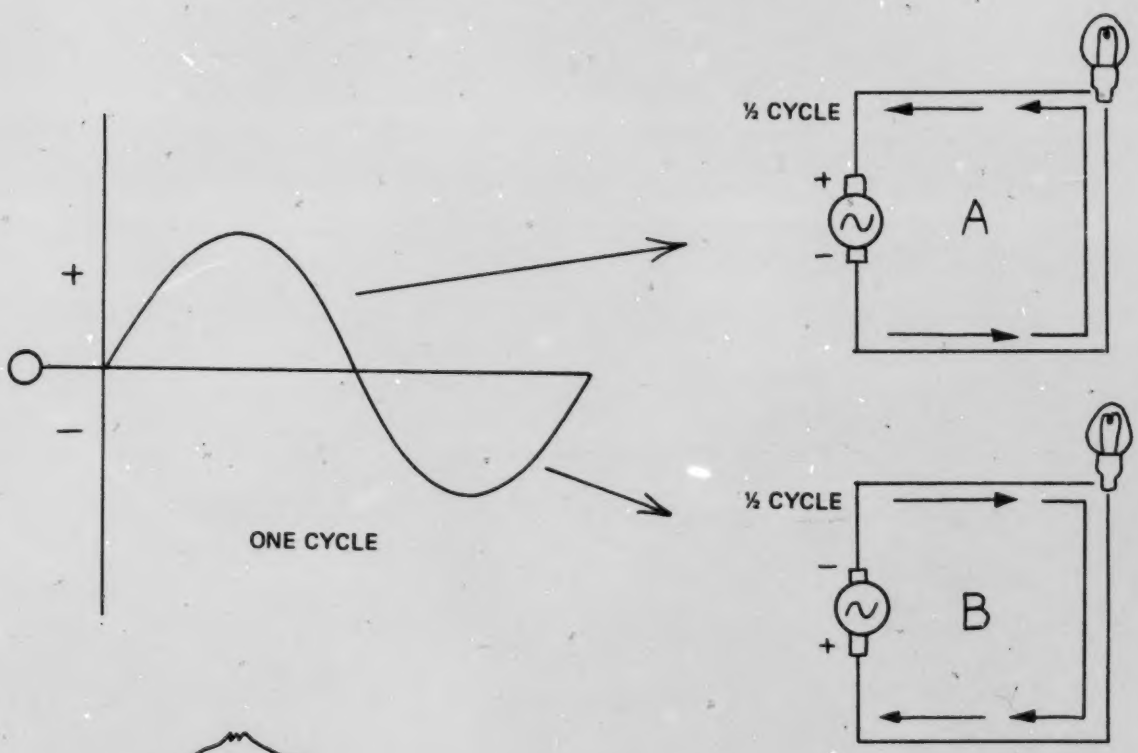


AC GENERATOR

AC voltage means the positive terminal becomes negative and then positive again. This happens 60 times each second.

There are 60 *cycles* in one second. Each cyele is a complete change of direction – from positive to negative and back.

The picture below shows what one cycle would look like if it were something we could see. It looks like a wave in the ocean.



Look at this circuit. See how the terminals "change places" each ½ cycle.

ASSIGNMENT:

1. AC means _____ _____.

2. The AC voltage _____ produces energy to push and pull electrons.

    a. terminal
    b. cycle
    c. energy
    d. generator

3. The positive terminal becomes the negative terminal _____ times each second.

4. There are _____ cycles in a second.

5. Alternating means moving _____ and _____.

UNIT VII – VOLTAGE

Frequency **Lesson 3**

OBJECTIVE:

When you have completed this lesson, you will be able to define frequency and give two units of frequency.

VOCABULARY:

frequency (frē'-kwən-si) – how often a thing happens; in electricity, the number of cycles of voltage or current each second.

INFORMATION:

The word *frequency* in electricity means the number of cycles each second. The abbreviation *cps* stands for *cycles per second* (cycles each second).

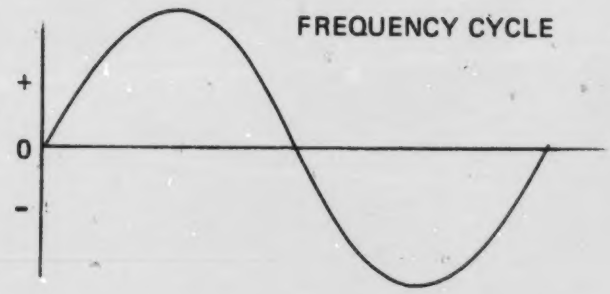
You know that:

Voltage is measured in volts.
Current is measured in amperes.
Resistance is measured in ohms.

Now you will know that:

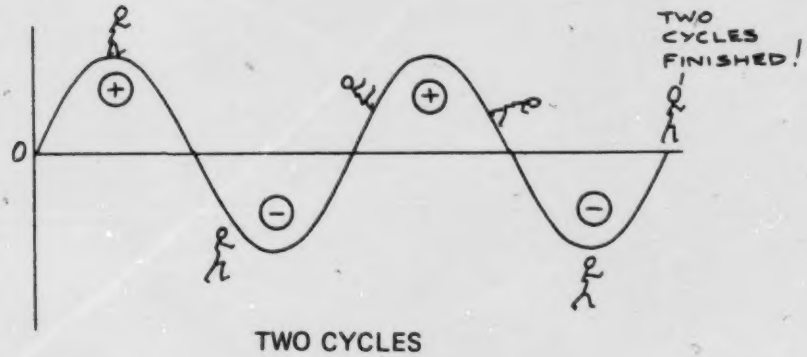
Frequency is measured in *hertz* (Hz)
1 Hz = 1 cps

In the United States, the frequency of AC current is almost always 60 Hz.



The number of times each second that the electrons travel from *zero* to *positive*, to *zero*, to *negative*, to *zero*, is *60*.

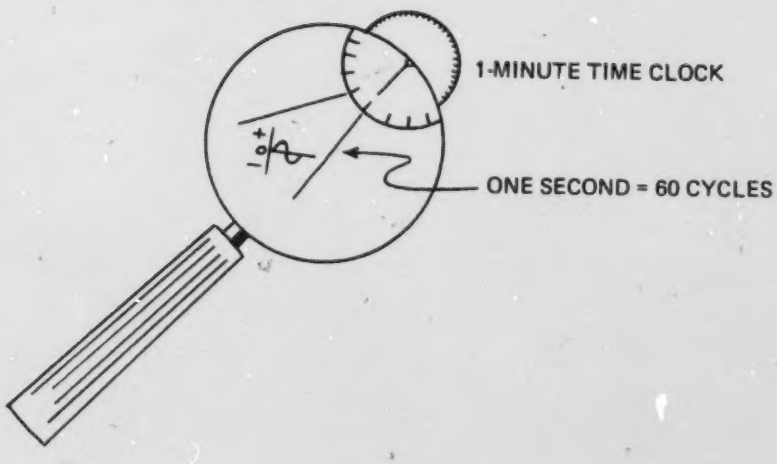
The picture below is a fun way of showing what an AC cycle is.



TWO CYCLES

He only has to do that 58 more times before one second is finished.

Now, when you see *60 cps*, you will know that it means *60 cycles per second,* or 60 hertz. This is the frequency of alternating current in this country.



60 of those waves happen before the clock hand reaches the next mark.

ASSIGNMENT:

1. Frequency and _____ mean the same thing.

2. What does cps mean? _____ _____ _____.

3. What unit is frequency measured in? _____.

4. What is the frequency of alternating current? _____

5. How many seconds does it take to make 60 cycles?_____

UNIT VII – VOLTAGE

Step-Down Transformer **Lesson 4**

OBJECTIVE:

When you have completed this lesson, you will be able to describe how a step-down transformer works.

VOCABULARY:

reduce (rē-düs′) – to bring down; lower

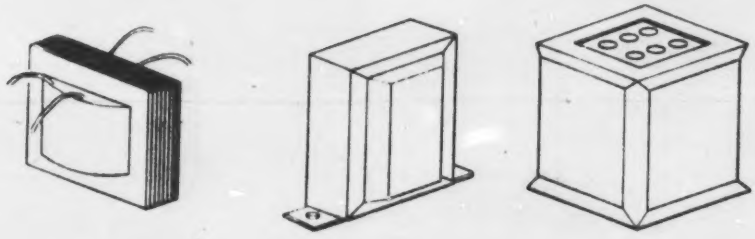
incoming (in′-kum-ing) – coming into a place

induce (in-düs′) – to produce electric current by magnetic lines of force that keep changing

apply (ə-plī′) – put on

INFORMATION:

These are transformers.



A step-down transformer reduces the incoming voltage.

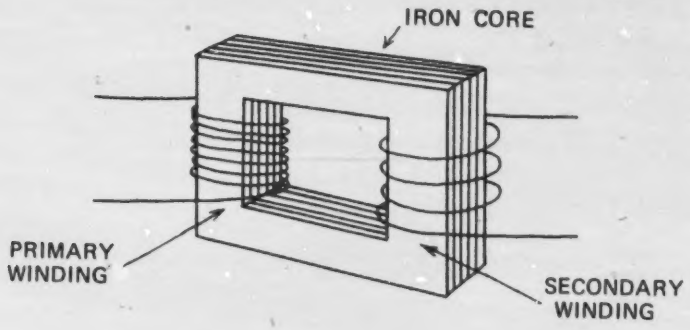
The following transformer is a step-down transformer.

It operates on an incoming voltage of 120-volt AC, and it gives you 10-volt AC.

The diagram shows you the inside of the transformer.

The *primary winding* has many turns.

The *secondary winding* has a few turns.

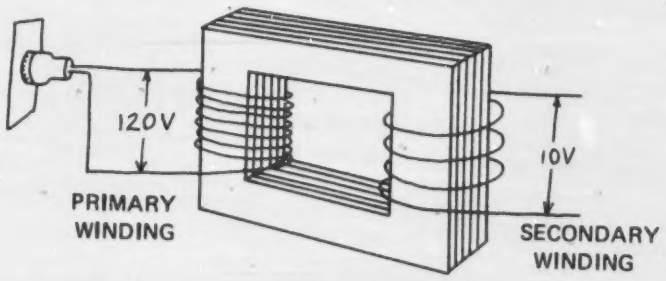


STEP-DOWN TRANSFORMER

The drawing below shows the voltage applied to the step-down transformer and the voltage you get from it.

The incoming AC voltage in the primary winding makes an electromagnet out of the iron core. This *induces* a voltage in the secondary winding.

The number of turns of wire sets the amount of induced voltage in the secondary winding. More turns give you more volts. Fewer turns give you less voltage.



ASSIGNMENT:

1. A step-down transformer _____ the voltage.

   a. reduces
   b. takes
   c. AC
   d. 10

2. The transformer in this lesson has _____ volts on the primary winding and produces _____ volts on the secondary winding.

3. The primary winding in this lesson has _____ turns than the secondary winding.

   a. fewer
   b. more
   c. 100
   d. 10

4. The secondary winding in this lesson has _____ turns than the primary winding.

   a. AC
   b. step-down
   c. fewer
   d. more

5. Which winding has less voltage? _____

UNIT VII – VOLTAGES

Operation of a Transformer **Lesson 5**

OBJECTIVE:

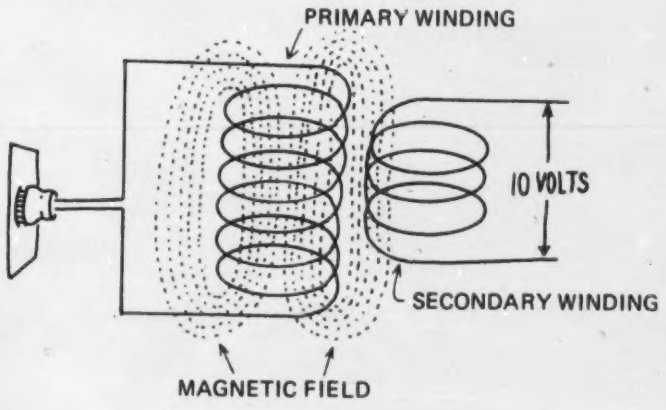
When you have completed this lesson, you will be able to describe the operation of a simple transformer.

VOCABULARY:

induction (in-duk'shən) – inducing a current in a coil of wire by magnetic lines of force from another coil.

INFORMATION:

AC current passes through the primary winding. This produces a magnetic field around the primary winding. (Review Unit V on Magnetism, starting with Lesson 3, page 150.)



How a Simple Transformer Works

When the direction of the AC current changes, the magnetic field dies and then starts again. It keeps dying and starting 120 times each second. The direction of the lines of force keeps changing.

The magnetic field cuts through the secondary winding. Each time it starts and stops it produces a voltage in the secondary winding. The direction of the voltage keeps changing.

We call this *electromagnetic induction.* The drawing shows how the lines of force cut through the secondary winding of a transformer.

ASSIGNMENT:

1. The magnetic field is first produced around the _____ _____.

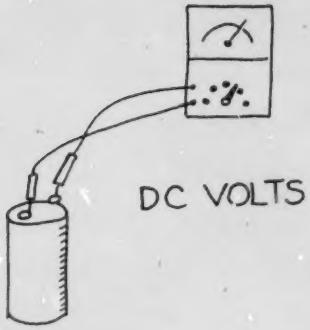
2. The magnetic field cuts through the _____ _____.

3. The voltage in a secondary winding comes from the starting and dying of the _____ _____.

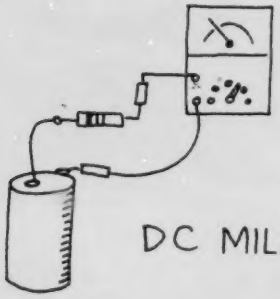
4. This is known as _____ _____.

5. Is the induced voltage AC or DC? _____

How to Measure Voltage & Current with a Meter



DC VOLTS



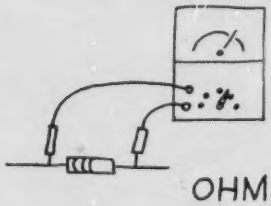
DC MILLIAMPERES

DC VOLTS

DC MILLIAMPERES - Ma.

OHMS Ω

METER SCALE



OHMS

UNIT VIII

Multimeter or V.O.M.

UNIT VIII – MEASURING VOLTAGE AND CURRENT WITH A METER

Ammeter Rules **Lesson 1**

OBJECTIVE:

When you have completed this lesson you will know the rules to follow when you use an ammeter.

VOCABULARY:

range (rānj) – distance between the smallest and the largest.

INFORMATION:

1. An ammeter measures only current (amperes).
2. Know what type of voltage source is supplying the current. Batteries supply DC, and most wall outlets supply AC.
3. Never use DC meters for AC current.
4. Never use AC meters for DC current.
5. Pick the current range you will measure on your meter. Always use the highest range first. This will protect your meter.
6. Never measure current bigger than the range of the meter.
7. If your needle swings past the scale to the right, quickly remove the meter leads.

8. Never use an ammeter to measure voltage.

9. Never use a voltmeter to measure current.

ASSIGNMENT:

1. An ammeter measures _____.
   (voltage, current)

2. Never use an ammeter to measure _____.
   (current, voltage)

3. Never use a voltmeter to measure _____.
   (current, voltage)

4. If the ammeter needle swings past the scale, you must _____.

5. Always use the _____ range first.
   (highest, lowest)

UNIT VIII – MEASURING VOLTAGE AND CURRENT WITH A METER

Ammeter Connection **Lesson 2**

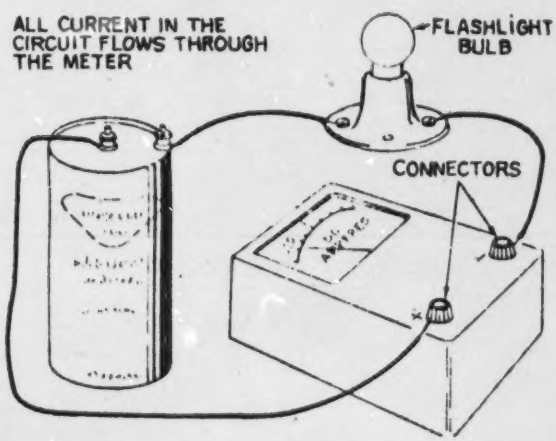
OBJECTIVE:

When you have completed this lesson you will know how to connect an ammeter to an electrical circuit to measure current.

INFORMATION:

To measure current, your ammeter must be connected *in series* with the circuit. (Review Lesson 4 of Unit III, page 83). The current being measured will flow through the meter.

Look at the picture below and trace the circuit. Start with the negative battery terminal – the post on the outside edge of the battery.



MEASURING DC CURRENT WITH AN AMMETER

Current flows from the battery, through the bulb, into the negative (–) post on the ammeter, through the meter, out through the positive (+) post of the meter and into the positive (+) post on the battery. The movement of electrons in the battery completes the path of current.

ASSIGNMENT:

1. An ammeter must be connected in _____ in the circuit.
   (series, parallel)

2. Current enters at the _____ post of the ammeter.
   (positive, negative)

3. Current leaves at the _____ post of the ammeter.
   (positive, negative)

4. The center post of the battery is _____.
   (negative, positive)

5. The post on the edge of the battery is _____.
   (negative, positive)

6. Tell in your own words what a series circuit is.

UNIT VIII – MEASURING VOLTAGE AND CURRENT WITH A METER

Reading Milliamperes **Lesson 3**

OBJECTIVE:

When you have finished this lesson you will be able to read the number of milliamperes on a milliammeter scale.

VOCABULARY:

milliampere (mil-i-am′-pēr) – a measure of current-flow. There are 1000 milliamperes in 1 ampere.

unit (ū′nit) – an amount of something that is used to measure that type of thing: a *foot* is a unit of length; a *minute* is a unit of time; an *ampere* is a unit of electric current.

scale (skāl) – a line with marks on it, used for measuring.

INFORMATION:

The unit of current is the *ampere.*

Most of the time electricians measure current that is less than 1 ampere. They often measure in *milliamperes.* There are *1000 milliamperes in 1 ampere.*

A light bulb may use $\frac{1}{2}$ ampere of current. It would use $\frac{1}{2} \times 1000$ milliamperes, or 500 MA of current.

Here is a milliampere scale.

It goes from 0 to 100 MA.

Below is a small part of this scale.

There are 10 little marks between 0 and 10 and between 10 and 20.

Each mark is a milliampere. The first mark means 1 MA, the second mark means 2 MA, and so on.

After the 10, the first mark means 10 + 1 or 11 MA. The second mark means 10 + 2 or 12 MA, and so on.

Look at the pointer below. It is pointing to the number 10. The reading is 10 MA.

Now look at this pointer.

It is pointing to the 5th mark after the 10. The reading is 10 + 5 or 15 MA.

Now look at this pointer. It is pointing to the 8th mark after the 10. The reading is 18 MA.

Do you think you know how to read a milliammeter? Try this.

If you said 65 MA, you were right.

There are other ammeter scales. Some read whole amperes. Some go from 0 to 10 MA. Some go from 0 to 1 MA. You will learn to read these scales when you go on in your study of Electricity.

ASSIGNMENT:

Give the reading of each scale:

1.

_____

2.

_____

3.

_____

4.

_____

5.

_____

UNIT VIII – MEASURING VOLTAGE AND CURRENT WITH A METER

Voltmeter Rules **Lesson 4**

OBJECTIVE:

When you have completed this lesson you will know the rules to follow when you use a voltmeter.

INFORMATION:

There are two types of voltmeters – a DC voltmeter and an AC voltmeter.

RULES:

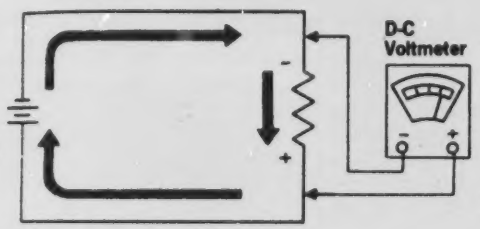
1. Use the correct meter for the type of voltage you measure.

2. If an AC voltmeter is used to measure a DC voltage, you will get a wrong reading.

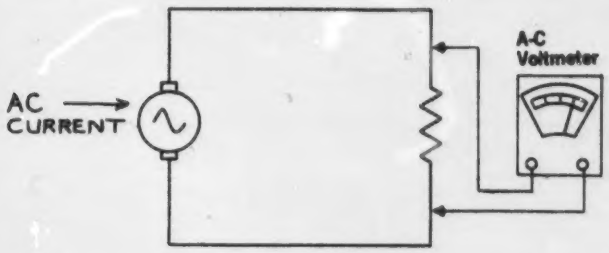
3. If a DC voltmeter is used to measure an AC voltage, you may damage the meter.

4. A voltmeter is *always connected in parallel* with the thing being tested. (Review Lesson 4 of Unit III, page 83).

5. When testing a DC voltage, connect the negative terminal to the negative side of the line; connect the positive terminal to the positive side of the line.



6. When testing an AC voltage, you do not have to worry about positive and negative terminals.



Some of the voltage ranges on voltmeters are:

1. 0 to 1.2 volts
2. 0 to 10 volts
3. 0 to 50 volts
4. 0 to 250 volts
5. 0 to 1000 volts

When reading small voltages, you will need to read amounts that are *less than 1*. You will read *decimals*.

For example, you may read 0.5V. As you know, that is five-tenths of a volt.

The reading 0.8V is eight-tenths of a volt, and so on.

ASSIGNMENT:

1. What type of meter measures DC voltage? _____

2. What type of meter measures AC voltage? _____

3. If a DC voltmeter is used to measure AC voltage, you may _____ the meter.

4. A voltmeter is always connected in _____ with the thing being tested.

5. When testing a DC voltage, you must connect the negative terminal to the negative side and the positive terminal to the positive side. True or False? _____

6. What is the reading on the DC voltmeter shown here?

UNIT VIII – MEASURING VOLTAGE AND CURRENT WITH A METER

Voltmeter Connection **Lesson 5**

OBJECTIVE:

When you have completed this lesson you will know how to connect a voltmeter to a battery.

VOCABULARY:

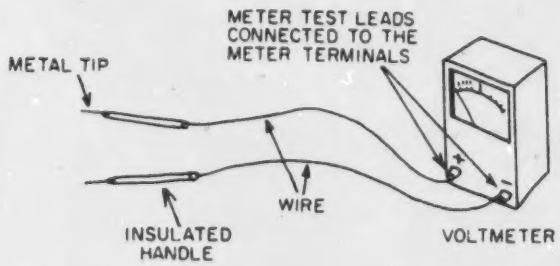
test lead (test' lēd') – an insulated wire with a bare tip. It makes it easy to test something without winding or hooking up wires.

flexible (flek'-si-bl) – easily bent.

INFORMATION:

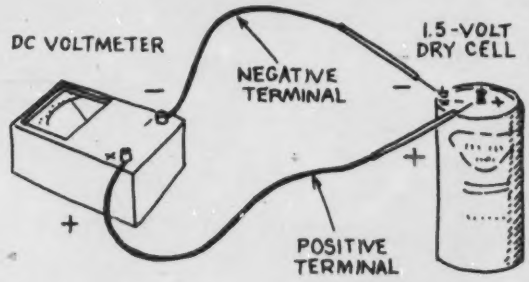
The voltmeter has two terminals. One (+) is usually red, and one (–) is usually black.

A voltmeter has two test leads. They are flexible insulated wires. See picture.



In this lesson we will discuss connecting only a DC voltmeter to a DC battery. This is often done to check the voltage of a battery.

The terminals of a DC voltmeter are marked (+) and (–). The negative (–) test lead is connected to the negative terminal of the battery. The positive test lead is connected to the positive (+) terminal of the battery.



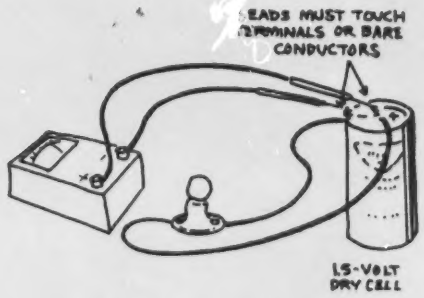
CONNECTION OF A VOLTMETER

Remember this rule:

Positive (+) test lead to positive (+) terminal of battery.
Negative (–) test lead to negative (–) terminal of battery.

If you do not follow this rule, the needle (pointer) on the meter will swing the opposite way and damage the meter.

This rule is not for measuring AC voltage.



MEASURING DC VOLTAGE

ASSIGNMENT:

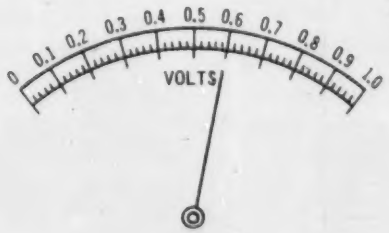
1. Positive test lead is connected to _____
   (negative, positive)
   voltage terminal.

2. Negative test lead is connected to _____
   (negative, positive)
   voltage terminal.

3. A voltmeter has two terminals. The color of the (+) terminal is usually _____. The color of the (–) terminal is usually _____.

4. If you connect the positive meter lead to a negative battery terminal and the negative meter lead to the positive battery terminal, the meter will be _____.

5. What is the reading on the DC voltmeter shown here?



UNIT VIII – MEASURING VOLTAGE AND CURRENT WITH A METER

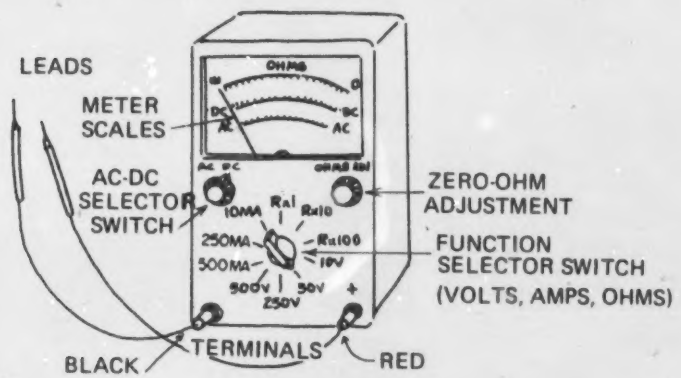
Multimeter **Lesson 6**

OBJECTIVE:

When you have completed this lesson you will know what a multimeter is and how it is used.

VOCABULARY:

combination (kom-bi-nā'-shən) – a whole thing made by putting together two or more different things.

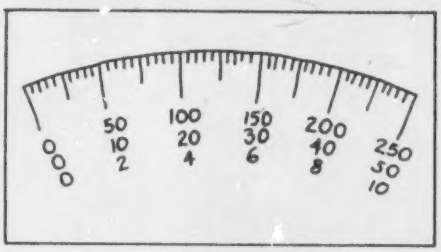


A MULTIMETER

INFORMATION:

A multimeter is a combination ammeter, voltmeter, and ohmmeter. It is used to measure AC and DC voltages, currents, and resistances. Another name is Volt-Ohm-Milliammeter (VOM).

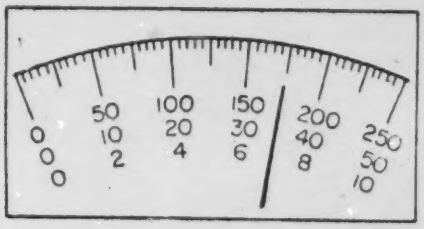
Below is one kind of multimeter scale. It has three ranges, 0–10, 0–50, 0-250.



MULTIMETER SCALE

This one scale can measure AC and DC voltage and current just by setting the FUNCTION SELECTOR SWITCH on the front of the meter to the proper position. Of course, the meter has to be connected properly to the circuit.

Below is a multimeter scale with its needle in position. Can you read the three ranges in volts?



1. What is the reading on the 0–10 range? _____

2. What is the reading on the 0–50 range? _____

3. What is the reading on the 0–250 range? _____

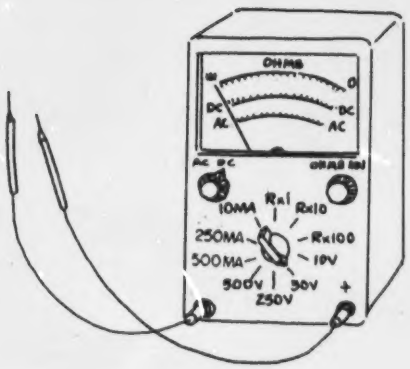
Answers:

1. The 0 to 10 range: 7 volts

2. The 0 to 50 range: 35 volts

3. The 0 to 250 range: 175 volts

ASSIGNMENT:



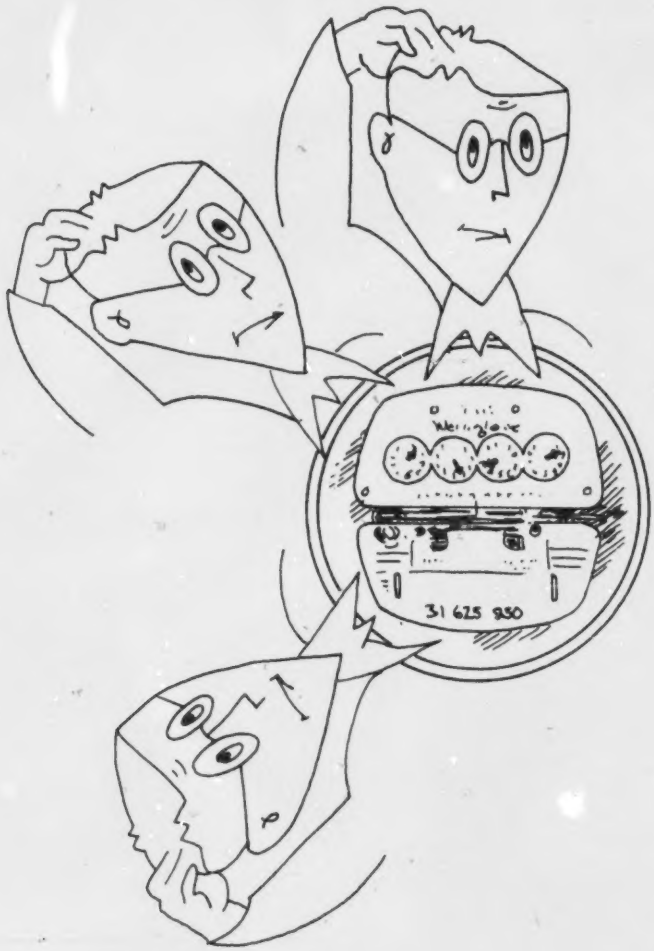
1. In the meter above, if the AC-DC Selector switch is on DC, would you read the (*top, middle, bottom*) part of the scale?

   _____

2. Another name for a multimeter is _____.

3. A multimeter measures voltage, current, and _____.

WATT-HOUR METER



UNIT IX

UNIT IX – WATT-HOUR METER

The Watt and Kilowatt **Lesson 1**

OBJECTIVE:

When you have completed this lesson you will know what a watt is and what a kilowatt is.

VOCABULARY:

rate (rāt) – speed; how fast something is done

wattage (wot′-ij) – amount of power used, measured in watts

rating (rāt′-ing) – the amount of power that an appliance will use – as printed by the manufacturer on the nameplate.

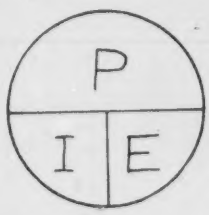
INFORMATION:

Power is the rate of doing work – the amount of work that can be done by something in a certain amount of time.

A *watt* is the unit of electric power.

One watt is the power used when 1 amp of current is forced through a circuit by a pressure of 1 volt.

The formula for finding watts is –



P = watts (power)
I = amperes
E = volts

This "pie" formula is used just like the pie with E, I, and R in it. Review that now. (See Lesson 3 of Unit VI, page 177.

The *kilowatt* is the unit used to measure large amounts of electrical power.

One kilowatt = 1000 watts

Below are some problems for the class to solve.

1. A soldering iron uses 5 amps of current at 110 volts. How much power does it use?

   P = I X E
   P = 5 X 110
   P = 550 watts (Answer)

2. How much power does an electric range (stove) use if it takes 35 amps of current at 220 volts?

   P = I X E
   P = 35 X 220
   P = 7,770 watts (Answer)

3. How many kilowatts does the range in problem 2 use?

   There are 1000 watts in 1 kilowatt. To find the number of kilowatts, we divide the number of watts by 1000.

```
      7.7
1000) 7700.0
      7000
       700
       700
```

7.7 kw (Answer)

4. The nameplate on a toaster says that it is rated at 935 watts. At 110 volts, how much current will the toaster use?

The formula for current is

$$I = \frac{P}{E}$$

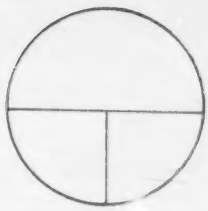
$$I = \frac{935}{110}$$

$$I = 8.5 \text{ amps (Answer)}$$

$$\begin{array}{r} 8.5 \\ 110 \overline{)\ 935.0} \\ \underline{880} \\ 550 \\ \underline{550} \end{array}$$

ASSIGNMENT:

1. The watt is the unit of electric _____.



2. What is the formula for watts? Write in the letters.

3. What is the word for each letter in the formula?

   a. _____
   b. _____
   c. _____

4. A hand iron uses 10 amps at 100 volts. How many watts does the iron use? _____

5. How many amps of current will a clothes dryer use at 220 volts if its wattage rating is 1320 watts? _____

6. One kilowatt = _____ watts.

7. Your instructor will give you three appliances – like a toaster, an iron, and a soldering iron. Write the wattage rating of each. You will find it on the nameplate.

   a.
   b.
   c.

8. Write the number of kilowatts in:

   a. 5000 watts _____
   b. 2500 watts _____
   c. 15,000 watts _____

UNIT IX – WATT-HOUR METER

Reading a Watt-Hour Meter **Lesson 2**

OBJECTIVE:

When you have completed this lesson, you will be able to read a watt-hour meter.

VOCABULARY:

dial (dī'əl) – a circle with numbers on it and a pointer. It tells how much there is of something.

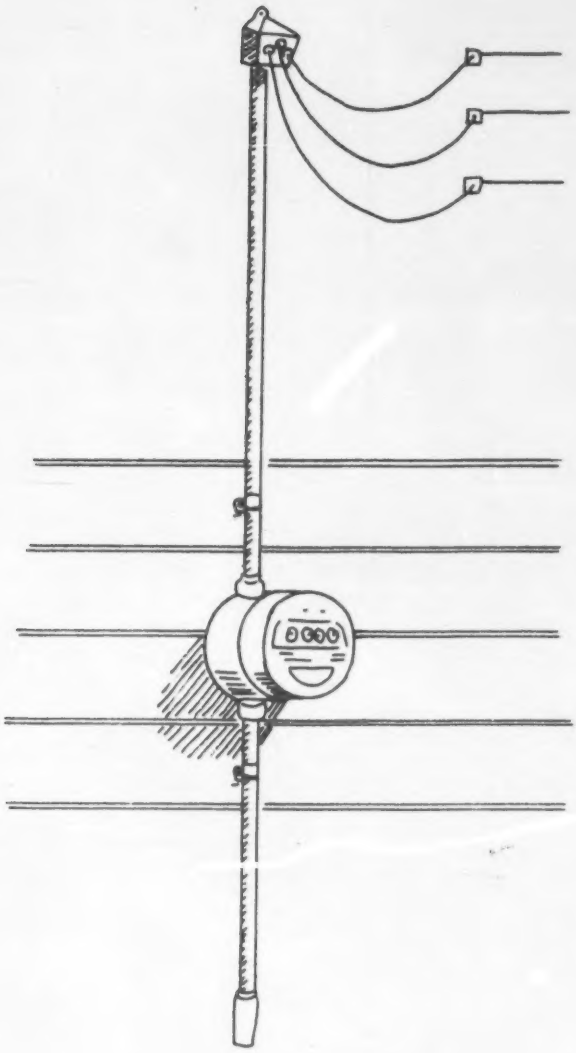
INFORMATION:

The amount of electricity you use in your home is measured on a *watt-hour meter.*

One watt-hour is the use of 1 watt of electric power for 1 hour.

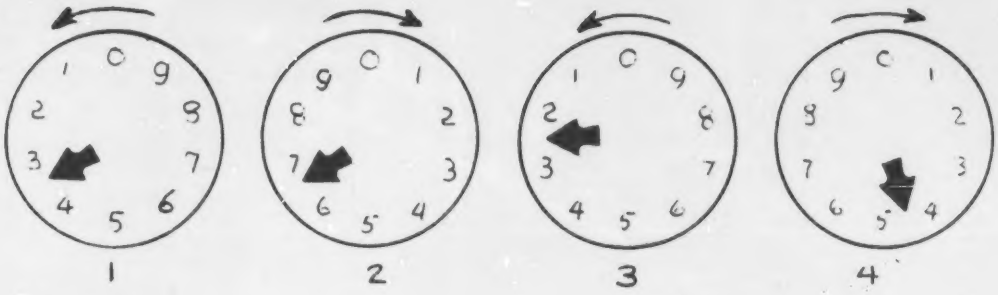
One kilowatt-hour is the use of 1 kilowatt of electric power for 1 hour.

Most watt-hour meters are on the outside of the house.



WATT-HOUR METER ON HOUSE

Where is the watt-hour meter on your house? Is it inside or outside the house?



This watt-hour meter reads 3,624 kilowatt-hours

The four dials you see in the picture are on the watt-hour meter on your home.

To read this meter, you must read each dial. *Follow the arrows.* Start with the 1 and go around to the 9. The large arrow inside the dial shows the number it has just passed over. In the picture above,

The first dial shows *3.*

The second dial shows *6.*

The third dial shows *2.*

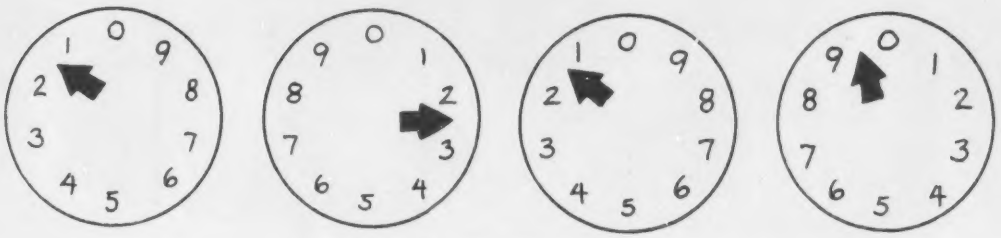
The fourth dial shows *4.*

The number of kilowatt-hours (KWH) is 3,624.

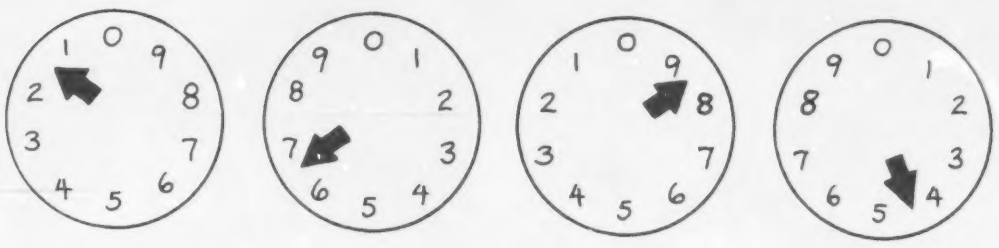
QUESTION: How many *watt-hours* would this be? Each kilowatt is 1000 watts. So each kilowatt-hour is 1000 watt-hours. We multiply the number of kilowatt-hours by 1000. We get 3,624,000 W-hr.

ASSIGNMENT:

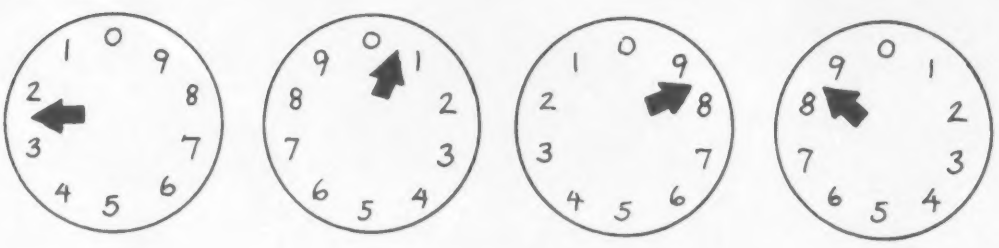
Write the number of kilowatt-hours for each set of dials.

1. 

Answer: _____

2. 

Answer: _____

3. 

Answer: _____

UNIT IX – WATT-HOUR METER

Your Electric Bill **Lesson 3**

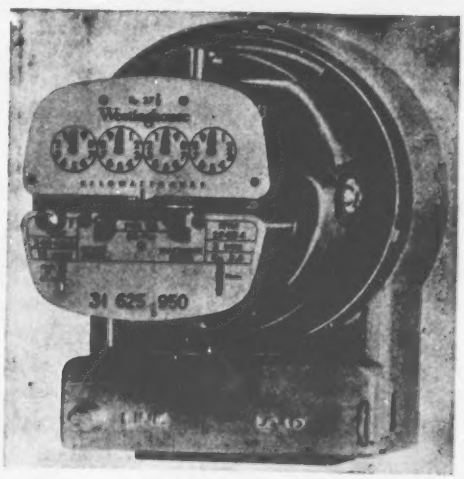
OBJECTIVE:

When you have completed the lesson, you will be able to figure your electric bill.

INFORMATION:

The electric company puts a watt-hour meter on your home to measure the electricity you use each month. You pay a certain amount for each kilowatt-hour (kWh) you have used.

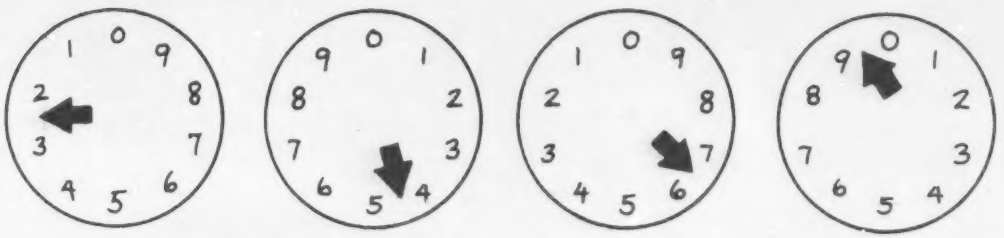
The meter keeps going all the time. Every time you use an electric light or appliance, the meter adds on a little more.

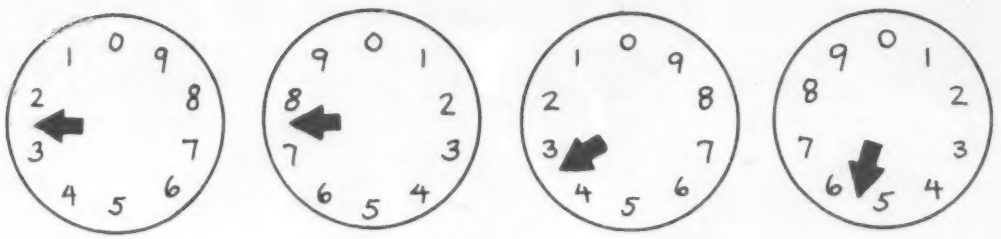


Four-dial single-phase kilowatt hour meter. *Courtesy of Westinghouse Electric Corporation.*

The next page shows you how to figure out your your bill for electricity.

Look at the meters below. The four dials in line 1 show the meter reading for June. The dials in line 2 show the meter reading for July. Subtract the June reading from the July reading. The answer is the electricity you used in one month.

(1) 

(2) 

The amount of electricity used in one month was 266 kilowatt-hours.

July 2,735
June 2,469
266 kWh

If each kilowatt-hour costs 5 cents, the electric bill is 266 X $.05 = $13.30

Let's use the formula:

$$kWh = \frac{W \times h}{1000}$$

A 100-watt light bulb is on for 10 hours.

How much will this cost at 6 cents per kilowatt-hour?

First we must find out how many kilowatt-hours of electricity the bulb used.

= W

= h

$$kWh = \frac{W \times h}{1000}$$

$$= \frac{100 \times 10}{1000}$$

$$= \frac{1000}{1000}$$

$$= 1 \text{ KWH.}$$

Now we will find out the cost.

We know that one kWh of electricity costs 6 cents.

The lamp used 1 kWh.

Its cost is 1 kWh X 6 cents.

Answer = 6 cents ($.06)

ASSIGNMENT:

1. The amount of electricity used in May was 250 kilowatt-hours. Each kWh costs 5 cents. How much was your electric bill that month?

_____

2. The meter reading on August 1 was 2,097.
   The meter reading on July 1 was 1,776.
   How many kilowatt-hours were used in July?

_____

3. In problem 2, the cost per kilowatt-hour is 6 cents. How much was the electric bill?

_____

4. The amount of electricity used in one month was 287 kWh.
   The cost for the first 200 kilowatt-hours is 6 cents per kWh.
   The cost for the next 200 kilowatt-hours is 5 cents per kWh.
   How much was the electric bill that month?

_____

5. The amount of electricity used in April was 355 kilowatt-hours. Each kilowatt-hour costs 5.5 cents. How much was your electric bill?

_____

UNIT IX – WATT-HOUR METER

Kilowatt-Hour Formula **Lesson 4**

OBJECTIVE:

When you have completed this lesson, you will be able to figure out the power used by an electric appliance and how much it costs to operate it.

INFORMATION:

Every electrical appliance has the wattage rating marked on the nameplate.

Some appliances use a lot of electric power. They will have a high wattage. An electric iron may use 1000 watts. A television set may use 750 watts.

Some things use very little power. A small electric bulb for a night-light may use 7½ watts. An electric clock may use 2 watts.

The kilowatt-hour formula below will help you to figure the electric power used in your home.

Kilowatt-Hour Formula

$$\text{Kilowatt-hours} = \frac{\text{Wattage of appliance X Number of hours used}}{1000}$$

or

$$\text{kWh} = \frac{W \times h}{1000}$$

ASSIGNMENT:

1. Write the kilowatt-hour formula.

2. With your teacher, find the wattage rating of three different appliances. Then find out the cost of using each one for 1 hour if the electricity costs 5 cents per kWh.

3. Jim's TV uses 450 watts. It was on for 40 hours last month. How much did the electricity cost at $.06 per kWh?

4. **Extra problem to try:**

   An electric clock uses 2 watts of power. How much does it cost to keep the clock running for a year at 5 cents per kWh?